DISTRIBUTED TEST AND EVALUATION OF AEROSPACE SYSTEMS:

The Joint Advanced Distributed Simulation Joint Test Force Experience

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Abstract

The Joint Advanced Distributed Simulation Joint Test Force (JADS JTF) is chartered by the U.S. Office of the Secretary of Defense (OSD) to determine the utility of advanced distributed simulation (ADS) for both developmental and operational test and evaluation (DT&E and OT&E). The program is nearing its completion and this paper is designed to provide a report on the utility of ADS in enabling the distributed test and evaluation (T&E) of aerospace systems.

The paper opens with a brief overview of ADS technology and distributed T&E, then provides a short description of the JADS Joint Test and Evaluation (JT&E) program. The main portion of the paper will discuss results, lessons learned and conclusions derived by the JADS JTF.

As this paper uses material directly from JADS reports prepared by many members of the JADS JTF, the credit for this paper goes to them. Readers are encouraged to seek more information on the JADS web site (http://www.jads.abq.com) which will be active until March 2001.

Overview of ADS

Since the mid-1980s, rapidly evolving information systems technology has been put to work in support of U.S. Department of Defense (DoD) needs. Early efforts were conducted jointly by the Defense Advanced Research Projects Agency and the U.S. Army. This early project was named Simulation Network (SIMNET) and it was sharply focused on training applications. Conceptually, the project was directed toward linking training devices (simulators) with human operators in the loop at distributed sites in a common virtual environment in near real time. SIMNET evolved to distributed interactive simulation (DIS), a technology implementation which is more flexible and far reaching. Formal industry standards have been established for DIS. In turn, DIS is giving way to high level architecture (HLA), a technical approach championed by the U.S. Defense Modeling and Simulation Office.

JADS uses a more generic term for the technology – ADS. This is defined as the technology and procedures that provide a time and space coherent, interactive synthetic environment through geographically distributed and potentially dissimilar simulations. Any combination of live, virtual, or constructive simulation of people and/or equipment can be used. ADS is the concept; DIS and HLA are applications of ADS.

Overview of Distributed T&E

ADS is the enabling technology that allows the T&E professional or developmental program office to link geographically separate resources together for a T&E event. Examples of assets that can be linked together include digital models of your system under test (SUT), digital representations of weapon systems or weapon flyouts, wargaming models, hardware-in-the-loop or system integration laboratories, human-in-the-loop simulators, and actual pieces of equipment either in a laboratory or field condition.

Distributed T&E architectures can be tailored to meet the need of the user in two ways. First, just the assets needed for a particular test may be linked, avoiding unnecessary cost and complexity. Second, the level of fidelity needed for a particular interaction may be linked. For instance, if you need the inputs from a live unmanned aerial vehicle (UAV), it can be linked in. If not, perhaps a digital representation of the UAV is adequate.

Distributed T&E provides the user the opportunity to gain more resources for a test than what may normally be available, as well as introduce higher levels of fidelity into the system development process than has been traditionally available.

Overview of JADS JT&E

Background

Because of widespread interest in using ADS technology to support T&E, the JADS JT&E program was nominated for feasibility study in 1993. The nomination was motivated by the T&E community's concern about long-standing test constraints and limitations, and the potential utility of ADS for relieving some of those constraints and limitations. However, there was widespread skepticism that ADS might not be able to deliver high-quality data demanded by the T&E community. The Services concurred with the need for a rigorous examination of ADS utility to testing and OSD’s Director of Test, System Engineering and Evaluation chartered JADS as a full joint test program.

JADS JT&E Charter

The basic JADS JT&E program was chartered in October 1994 to investigate the utility of ADS for both DT&E and OT&E. More specifically, JADS was to investigate the present utility of ADS, to identify critical constraints in using the technology, to develop the methodologies in using ADS in various T&E applications, and to provide growth requirements for ADS so that as it matures it better meets the needs of the T&E community.

At the time of chartering, OSD tasked JADS to investigate the possibility of specifically examining ADS utility to Electronic Warfare (EW) T&E. This additional facet of the program was subsequently chartered in August 1996.

Test Approach

To accomplish this charter, JADS conducted three series of ADS-enhanced tests in widely different areas to determine the utility of ADS. Representative “systems under test” were used, ones that had already undergone testing and had been fielded. Significant system performance data was then available for comparison with the data obtained in the tests using ADS as a methodology. The three specific test programs were the System Integration Test (SIT) utilizing two air-to-air missiles [AIM-9M Sidewinder and AIM-120 Advanced Medium Range Air-to-Air Missile (AMRAAM)]; the End-to-End Test (ETE) using the Joint Surveillance Target Attack Radar System (Joint STARS) as a representative command, control, communications, computer, intelligence, surveillance and reconnaissance (C4ISR) system; and the EW Test, utilizing the ALQ-131 self-protection jammer (SPJ).

System Integration Test

SIT evaluated the utility of using ADS to support cost-effective testing of an integrated missile weapon/launch aircraft system in an operationally realistic scenario. The purpose of SIT also included the evaluation of the capability of the JADS Test Control and Analysis Center (TCAC) to control a distributed test of this type and to remotely monitor and analyze test results.

SIT consisted of two phases, each of which culminated in fully linked missions. The missions simulated a single shooter aircraft launching an air-to-air missile against a single target aircraft. In the Linked Simulators Phase (LSP), the shooter, target, and missile were all represented by hardware-in-the-loop (HWIL) laboratories. LSP testing was completed in November 1996. In the Live Fly Phase (LFP), the shooter and target were represented by live aircraft and the missile by a HWIL laboratory. LFP testing was completed in October 1997.

Linked Simulators Phase. The LSP test concept was to replicate a previous AIM-9M-8/9 live fire profile in an ADS configuration and compare missile results for the LSP trials to those from the live fire test. The LSP test configuration is shown in Figure 1.

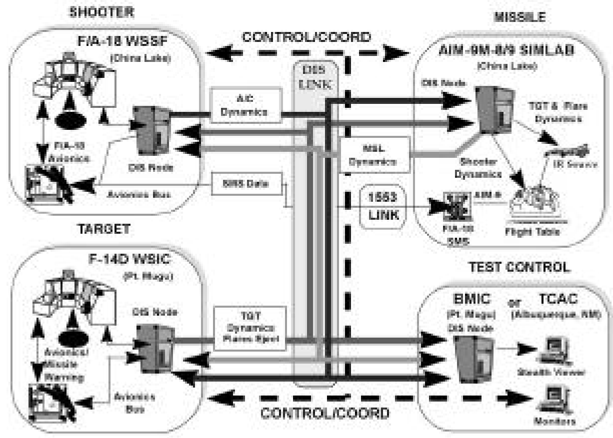

Figure 1. Linked Simulator Phase Configuration

The F/A-18 Weapon System Support Facility (WSSF) at China Lake, California, and the F-14D Weapon System Integration Center (WSIC) at Point Mugu, California, were the shooter and target, respectively. The shooter “fired” the AIM-9 in the Simulation Laboratory (SIMLAB) HWIL facility at the target which could respond with countermeasures. Runs were controlled from a test control center which ensured all nodes were ready for each run, issued start/stop directions, and processed data packets for real-time analysis of system performance. Test control was exercised from the Battle Management Interoperability Center (BMIC) at Point Mugu while the JADS JTF was physically relocating. Control switched to the JADS TCAC in Albuquerque, New Mexico after the move was complete.

Live Fly Phase. The LFP test concept was to replicate previous AMRAAM live fire profiles in an ADS configuration and compare missile results from the LFP trials to those from the live fire tests. In the LFP, ADS techniques were used to link two live F-16 aircraft (flying on the Gulf Test Range at Eglin Air Force Base, Florida) representing the shooter and target to an AMRAAM HWIL laboratory (also at Eglin) representing the missile. This configuration allowed data from live sources to drive the HWIL laboratory for more realistic missile results and is shown in Figure 2.

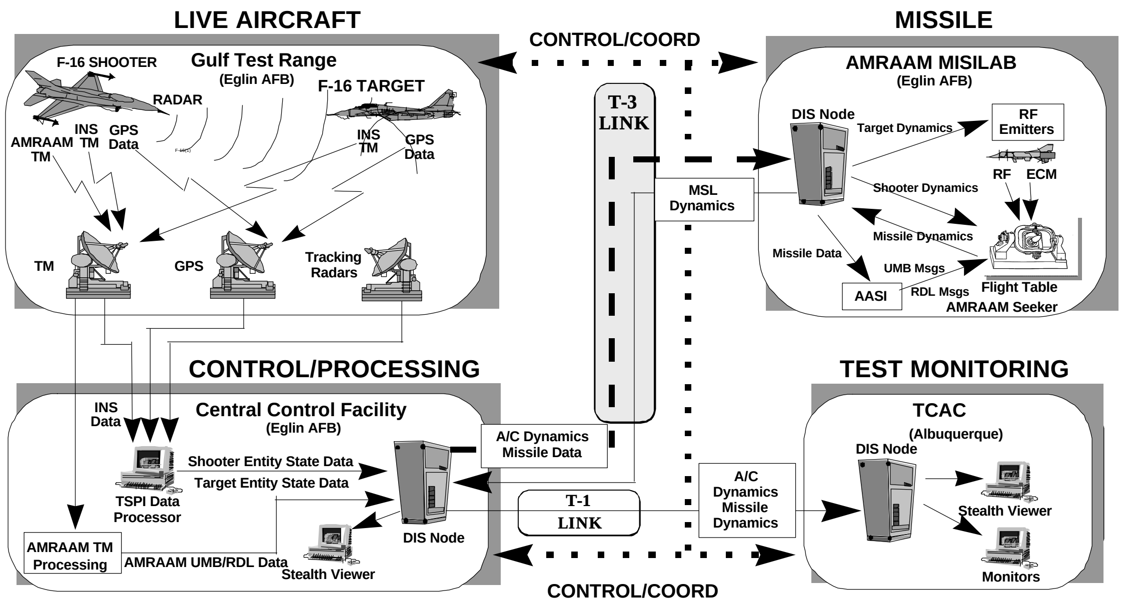

Figure 2. Live Fly Phase Configuration

Global positioning system (GPS) and telemetry (TM) data were downlinked from the aircraft and passed to the Central Control Facility (CCF) at Eglin. GPS, inertial navigation system (INS), and tracking radar data for each aircraft were combined by the time-space-position information (TSPI) Data Processor (TDP) in the CCF to produce optimal entity state solutions. The aircraft entity state data were transformed into DIS protocol data units (PDUs) and transferred to the AMRAAM HWIL simulation at the Missile Simulation Laboratory (MISILAB) over a T-3 link. The shooter aircraft “fired” the AMRAAM in the MISILAB at the target and provided data link updates of the target position and velocity to the missile during its flyout. The AMRAAM seeker was mounted on a flight table and responded to radio frequency (RF) sources in the MISILAB which simulated the seeker return from the target, the relative motions of the target and the missile, and electronic countermeasures (ECM). A link between the CCF and the JADS TCAC allowed JADS personnel to monitor and record the simulated intercepts.

End-to-End Test

The ETE used distributed simulations to assemble an enhanced environment to be used for testing C4ISR systems. The object was to determine if ADS can provide a complete, robust set of interfaces from sensor to weapon system including the additional intermediate nodes that would be found in a tactical engagement. The test traced a thread of the battlefield process from target detection to target assignment and engagement at corps level using ADS. Figure 3 illustrates the basic test architecture.

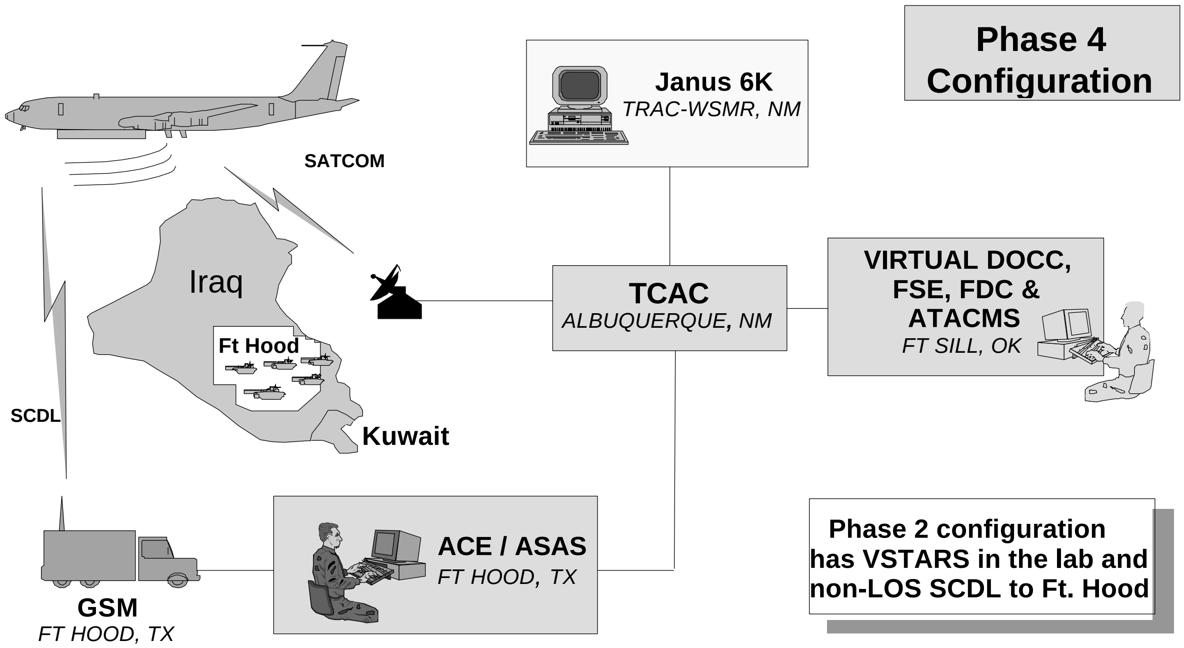

Figure 3. End-to-End Test Architecture

The ETE was a four-phased test. Phase 1 was largely developmental – constructing the various components necessary to executing later phases of testing. These components included a high fidelity emulation of the Joint STARS radar processes, called Virtual Surveillance Target Attack Radar System (VSTARS), which included both moving target indicator and synthetic aperture radar modes of operation. Phase 2 linked representative entities for the end-to-end process while the “system under test” was in a laboratory environment enabling JADS to explore the utility of ADS in the DT&E and early OT&E of a C4I system. Phase 3 hosted VSTARS on board the actual Joint STARS aircraft and performed final integration testing. Phase 4 was an actual live open air test with the aircraft airborne, with the environment augmented by ADS.

Electronic Warfare Test

JADS EW Test was chartered separately by OSD to examine the utility of ADS in EW T&E. To allow JADS to conduct a broad analysis of this domain and remain within very tight fiscal constraints, a “multi-vectored” approach was employed. JADS leveraged off the U.S. DoD HLA Engineering Prototype Federation for lessons learned in constructing and implementing a distributed architecture for EW T&E. At the bequest of DoD’s CROSSBOW Committee, JADS directed the Threat Simulator Linking Activity Study, which delineates how to link DoD’s EW test facilities using HLA. Third, JADS participated with the U.S. Army in its Advanced Distributed Electronic Warfare System test, a concept that provides EW effects on communications gear in the open air environment without the actual EW open air emissions.

SPJ Test

The SPJ test was designed as a three-phased test focusing on the U.S. DoD EW test process, and utilized the ALQ-131 as its “system under test.” Phase 1 was a non-ADS test of the SPJ on an open air range (OAR), augmented with data obtained by testing the ALQ-131 in an HWIL facility. The purpose of this test was to establish a baseline of environment and performance data which was used to develop the ADS test environment for the following phases and was the basis for determining the validity of ADS test results. Phase 2 was a test of a high-fidelity real-time digital system model (DSM) of the ALQ-131 linked with HWIL terminal threats and a constructive model of an Integrated Air Defense System (IADS). The threat laydown from the OAR was replicated in the synthetic ADS environment and the ALQ-131 was flown, via a scripted flight profile developed from the actual OAR flights, through the IADS, engaging the high-fidelity terminal threats. Phase 3 was a test of the SPJ installed on an actual aircraft located in an Integrated System Test Facility (ISTF). The facility was linked with HWIL threats and the constructive model of the IADS using the same threat laydown as the previous test and controlled by the same scripted flight profile. Figure 4 illustrates Phases 2 and 3 of the SPJ test.

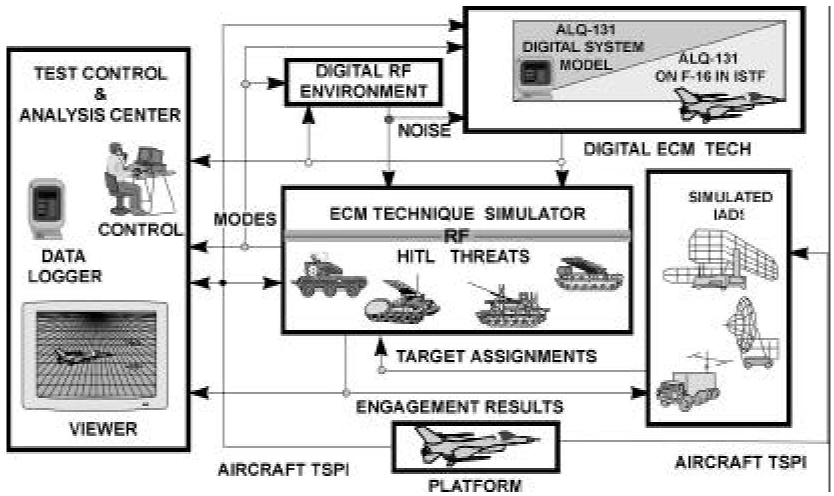

Figure 4. Self-Protection Jammer Phases 2 and 3

JADS JT&E Test Results, Lessons Learned and Conclusions

This section will briefly summarize the test results, lessons learned and conclusions for the SIT and ETE tests. The phase and utility reports for the EW test are being prepared at the time of this writing, so are not included in this paper. Because of the fundamental difference between the SIT's two test phases, LSP and LFP, they will be addressed separately.

Linked Simulators Phase

LSP Test Results The key results from LSP testing are as follows:

- The simulation facilities were properly linked, and the missile flyouts were valid for the target representation in the SIMLAB. However, this target representation differed somewhat from the target data originating from the Weapon System Integration Center (WSIC).
- The manual method for replicating a given profile resulted in very good run-to-run reproducibility of the engagements.
- The average latency of all entity state data during the final mission were relatively small (<100 milliseconds from simulation to simulation) and consistent run-to-run. However, relatively large random latency variations were often observed which resulted in an uncertainty in the target location, as perceived in the SIMLAB.
- The ADS network provided ample bandwidth and no loss of connectivity during testing.
- There were no significant ADS-induced errors.
- The reliability of the long-haul network was very good, and the availability of the complete LSP ADS configuration was on the order of 85%.
- Test control procedures were refined throughout the preparation process and worked well during testing.

LSP Lessons Learned Key LSP technical and programmatic lessons learned are:

- Accurate coordinate transformations are necessary. They must be verified and validated at each site and then revalidated during end-to-end testing as early as possible in the test phase.
- Quantitative validation has limitations. JADS intent was to quantitatively verify missile simulation performance against live fire data. However, as only one live fly event was available to support the process, a modified approach including both quantitative and qualitative methods was used, and successfully identified invalid results.
- Network interface units (NIUs) need improvement. NIUs are necessary if two nodes cannot communicate directly in a common language. They can be a major source of both errors and processing delays. Better direct user control of the content of the data and network communications is needed.
- Common ADS-related hardware and software is needed. In the LSP, it was difficult to get the ADS network to behave in a uniform fashion due to the many different types of interface hardware, communications equipment (routers), and interface software versions.
- Latency variations were significant. Processing delays were the primary culprit here.
- Time sources must be synchronized off the same time source and then must be validated at each test site prior to project operations to ensure accurate, synchronized time is precisely recorded at each test site.
- Special test equipment is needed for check-out and verification of the ADS architecture. Without this equipment, trial and error becomes the norm when (not if) problems crop up.
- The requirements for an ADS test must be clearly defined early in the test planning phase. This includes user requirements, support agency's stated actions, and operations security requirements. Planning and coordination details will be much more involved than in a traditional, non-ADS test.
- Get "system under test" experts involved from the beginning.
- Test communications requirements must be addressed early in the test planning phase. This is necessary to ensure effective communications during the test. Also, a linked test should have multiple (more than two) communications nets with easy, selectable access to all the nets from multiple locations within the site. Finally, the capability for secure video teleconferencing pays big dividends during planning, coordination, and post-test debriefs.
- A stepped build-up approach should be used. First, a systematic check-out of the stand-alone simulators (live, virtual or constructive) is needed. Next, direct (non-DIS) links should be used during test build-up. Finally, structured testing of the network must be performed prior to, and independent of, the linked testing times and the simulation laboratories to validate transmission/reception rates, bandwidth utilization, latency, data transmission and reception, etc., prior to commencing project test periods.
- Linking of facilities using ADS can require significant facility interface hardware and software development. ADS implementation is not "plug and play," at least for some time.
- Local (on-site) test monitoring/control should be used prior to remote test monitoring/control.
- Tight control of the aircrew is not desirable. Give them the critical parameters and switchology to meet the test objectives and allow them to make tactical decisions, fly the "aircraft," operate the weapon system, etc.
- Additional time is needed before the beginning and after the end of each testing period. One hour is recommended for set-up, and two hours at the end for data logging, data archiving, data transfer, and laboratory reclassification.
- Briefings are needed before and after each mission.
- Effective data management is needed, as ADS can generate mountains of data. A comprehensive plan will clearly identify the data to be collected at each site, on-site processing of the data, and data to be transferred to the analysis center.
- Adequate time must be allowed for data analysis between test events. Analysis procedures should be rehearsed to better understand the amount of time needed for this analysis.
- Configuration control is essential. This one obvious area was one of great challenge considering the many sites involved and the multiple uses of each site.

<u>LSP Conclusions</u> The LSP ADS configuration has utility for:

- Missile weapon/launch aircraft system integration T&E.
- Parametric studies, due to good pilot manual reproducability of the profiles.
- Rehearsal and refinement of live engagement scenarios.
- T&E with closed-loop shooter/target interactions (e.g., prelaunch tactics evaluation).

- T&E with open-loop missile/target interactions (e.g., the missile reacts to the target, but the target does not react to the missile).

Live Fly Phase

LFP Results The key results from LFP testing are as follows:
- Live aircraft were properly linked to the missile HWIL laboratory and the MISILAB generated valid AMRAAM data during the engagement.
- Accurate TSPI solutions were generated by the TSPI Data Processor (TDP) to the order of one to three meters in position and one meter per second in velocity. This well exceeded MISILAB accuracy requirements.
- The shooter and target TSPI data were properly synchronized to each other and to the umbilical and data link messages for input to the MISILAB simulation.
- Latencies during testing were relatively stable and consistent, but fairly large. The total latency of the MISILAB simulation was about 3.1 seconds. This large value of latency was due to the processing and buffering of the TSPI data to produce accurate and smooth solutions and to the synchronization technique used.
- The ADS network provided ample bandwidth and no loss of connectivity during testing.
- There were no significant ADS-induced errors.
- Test control procedures worked well during testing with centralized test control exercised from the CCF.

LFP Lessons Learned Key lessons learned from LFP are:
- As in the LSP, a major lesson learned is that stand-alone simulation facilities (for live, virtual or constructive entities) can require significant modifications before effective linking is possible.
- Additionally, linking may require special purpose interfaces so as to accept inputs in real time. Development of such units must be factored into test planning.
- Key interfaces need realistic integration testing. Replaying data from a recorded mission worked well in most cases (and was most cost effective); however, some integration testing required a live mission.
- Early definition of network requirements was very advantageous. This was a major lesson from LSP that JADS took advantage of.
- Changes and upgrades to aircraft instrumentation delayed development. Specially instrumented aircraft were required to support the LFP flights. Due to the small number of such aircraft, the LFP schedule was very sensitive to periodic aircraft phase inspections, software upgrades, and higher priority missions.
- Merging several TSPI sources was advantageous. Real-time aircraft inertial navigation system (INS) and GPS data were combined to calculate more accurate kinematic estimates. When combined with the ground radars, solutions of one to three meters in position and one meter per second in velocity were achieved.
- A strong program manager or system integrator is needed to oversee facility development, due to the difficulty in coordinating several diverse facilities to successfully integrate an ADS-linked configuration.
- Use risk reduction tests for integration. A building block approach was used successfully to check out interfaces at the lowest level, then one or two resources at a time were added to integrate the linked configuration. These risk reduction tests were also useful for developing analytical tools.
- Several subnetworks should be used for voice communications. Three voice communications networks were needed to support more than 30 people at various locations, and a fourth network could have further aided decision making.
- Two-dimensional displays were needed at each node; they greatly enhanced the situational awareness of the `participants.
- Existing range procedures had to be modified for ADS. The existing test procedures were only written for individual facilities, so a new combined checklist was created for ADS applications.
- Laboratory replays served as an excellent method of test rehearsal.

LFP Conclusions The LFP ADS configuration has utility for:
- Missile weapon/launch aircraft system integration T&E, especially evaluation of the targeting messages supplied to the missile by the shooter.

- Rehearsal and refinement of live engagement scenarios.
- Tactics development involving closed-loop interactions between the shooter and target.
- Efficient testing utilizing an analyst-in-the-loop for timely feedback during the mission.

End-to-End Test

ETE Results The key results from ETE testing were:

- Both ADS configurations used in the test generated valid Joint STARS data, as judged by subject matter experts.
  -- It was specifically validated that Janus 6.88D represented vehicle behavior to the degree detectable by the Joint STARS, as judged by Joint STARS operators viewing vehicle movement presented by the Joint STARS operator workstation.
  -- Test participants could not identify any Joint STARS radar simulation process or function that limited their ability to perform their mission/job or altered their approach to their mission/job.
  -- The credibility of the Joint STARS data was enhanced by the use of actual operational hardware with trained operators whenever possible.
- Sufficient data were collected to support evaluation of most of the Joint STARS multiservice operational T&E measures. These measures were not evaluated by JADS analysts since the JADS objective was to evaluate ADS-based testing, not Joint STARS.
- When live and virtual entities were mixed using the live ETE test configuration, it was impossible to distinguish between them based upon size, color, contrast, and movement. However, the live and virtual areas could be distinguished based on the different scenarios used and the civilian traffic "clutter." The live area contained civilian traffic around Ft. Hood, and the virtual area contained simulated battlefield entities in Iraq. If the live entities had simulated a battle in Iraq, the live and virtual entities would have been indistinguishable.
- The ETE required only a small fraction of the T-1 bandwidth (1.544 megabits per second). This indicates that a much higher data transfer rate (e.g., more nodes or entities) could be applied to distributed testing without causing bandwidth problems.
- The live testing using the SATCOM link to the E-8C aircraft showed that all the available SATCOM link bandwidth was required for data transmission, and that buffering was needed at times to handle periods of heavy scenario activity. Without buffering, the SATCOM link exhibited an average latency of around two seconds. With buffering, the latency approached six seconds.
- The ETE test exhibited acceptable latency values. In other words, the latencies experienced during testing did not affect the validity of test results.
- The ETE test network was highly reliable during testing, largely because of the ETE test team's extensive pretest risk reduction efforts.
- Test control procedures were refined throughout the preparation process and worked well during testing.

ETE Lessons Learned Key lessons learned from ETE are:

- Simulations, when used in distributed testing, should be carefully planned and developed. Using reliable simulations is important for a successful test.
- Distributed testing often requires linkage among dissimilar facilities, network equipment, and simulations. However, careful planning can significantly reduce the potential for difficulties arising from network interface problems.
- Time sources must be synchronized using a "master clock" and then validated at each network node.
- Special test equipment and networking tools are necessary for distributed testing. The tool set must be able to rapidly isolate the specific cause of network and ADS/DIS problems.
- ADS test requirements must be clearly defined early in the test planning phase, since individual facilities are generally unfamiliar with conducting coordinated, distributed tests.
- Develop contingency plans that allow quick decisions on alternatives and prevent unexpected equipment and communications problems from completely disrupting the test.

- Use a stepped approach to testing where each successive ADS test builds on the success of earlier tests. This "test, analyze, fix, test" approach, in concert with structured, independent testing of the network, will greatly improve the chances for successful distributed testing.
- Risk reduction testing prior to actual test execution provided effective rehearsals and was helpful for troubleshooting.
- Detailed planning for data management is necessary before testing commences.
- Have a centralized test control center with test controllers who are extremely familiar with the test and network configuration.
- Personnel involved in a distributed test need to understand the "big picture." When people are geographically separated, it becomes easy for them to focus on their own individual portion of the test. When problems arise, personnel who understand the entire test and the overall network will find solutions much faster.

<u>ETE Conclusions</u> Key conclusions from the ETE Test are:

- The ETE live ADS configuration has utility for realistic OT&E to include mission-level testing of C4ISR systems.
  -- In contrast to ADS-supported testing, most traditional live C4ISR testing cannot be done at the mission level because of the unavailability and prohibitive cost of involving the required numbers of live battlefield entities and limited access to key real world systems because of their limited numbers and high usage.
  -- The use of ADS permits the number of targets to be greatly augmented by the seamless integration of live and virtual threat entities while operating the sensor/sensor platform in the actual operational environment.
  -- Realism and credibility of test results are enhanced by the use of actual operational hardware by trained operators and by the employment of the sensor in a real open-air environment subjecting it to actual background and clutter effects.
- The ETE laboratory ADS configuration has utility for:
  -- C4ISR DT&E, since laboratory/brass board SUT configurations can be used, and multiple repetitions of the same scenario can be performed for parametric testing.
  -- Realistic rehearsal and refinement of live test scenarios, since multiple repetitions of the scenarios can be performed using the same equipment operators as the live test.
  -- Early operational assessment of C4ISR system components prior to building them by using laboratory/brass board configurations for new components (e.g., sensor/sensor platforms) linked to existing tactical hardware manned with actual operators for the other components (e.g., command and control elements).
- Both ADS configurations have utility for C4ISR system training.
  -- Conventional training can be limited by the availability of those assets making up the C4ISR system's operational environment. ADS technology, by simulating those key assets, can provide longer periods of time for realistic operation of the C4ISR system.
  -- C4ISR system operators can take advantage of the additional training time provided by ADS technology to confirm current tactics and to test "what if" scenarios and new tactics.
  -- ADS simulations can help C4ISR system operators familiarize themselves with the maneuver tactics of foreign armed forces – valuable experience for possible future deployments.

<u>Electronic Warfare Test</u>

At the time of this writing, the JADS JTF is still compiling the test phase and EW utility reports. All of these reports will be available on the JADS web site (http://www.jads.abq.com) by 1 December 1999.

<u>Conclusions</u>

JADS was chartered to determine the truth as to whether ADS is, or is not, a feasible tool for T&E. Evidence is that ADS can bring many benefits to the table. However, one must be fully aware of the inherent limitations of the technology. Also, one would be well advised to learn from those who have practical experience in using ADS in the T&E arena. Distributed T&E is certainly not a panacea that will solve all of the problems and meet all of the requirements. However, it does appear to be a powerful tool, if used appropriately and intelligently, and should be considered in balance with other methodologies when developing a T&E program.

References

Portions of the following test plans and reports were used in preparing this paper:

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4. “System Integration Test Linked Simulators Phase Final Report,” JADS JT&E, July 1997
5. “System Integration Test Live Fly Phase Final Report,” JADS JT&E, March 1998
6. “Threat Simulator Linking Activities (TSLA) Study ADS Capabilities Assessment,” Georgia Technical Research Institute, April 1998
7. “The Utility of Advanced Distributed Simulation for Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance Systems Testing,” JADS JT&E, August 1999
8. “Report on the Utility of Advanced Distributed Simulation for Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance Systems Testing,” August 1999

Acronyms

Following are acronyms found in this paper's figures and not defined in the body of the paper.

Figure 1
A/C - Aircraft
IR - Infrared
MSL - Missile
SMS - Stores Management System
TGT - Target

Figure 2
AASI - Aircraft Avionics Simulation Interface
ECM - Electronic Countermeasures
RDL - Rear Data Link
UMB - Umbilical
TM - Telemetry

Figure 3
ACE - Analysis and Control Element
ASAS - All-Source Analysis System
ATACMS - Army Tactical Missile System
DOCC - Deep Operation Coordination Center
FDC - Fire Direction System
FSE - Fire Support Element
GSM - Ground Station Module
LOS - Line of Sight
OK - Oklahoma
SATCOM - Satellite Communications
SCDL - Surveillance Control Data Link
TRAC - U.S. Army Training and Doctrine Command Analysis Center
WSMR - White Sands Missile Range

Figure 4
ECM - Electronic Countermeasures
IADS - Integrated Air Defense System
RF - Radio Frequency
TECH - Technique